Identification and Assessment of Mechanisms for Technology Transfer

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1. The Need for Technology Transfer for SFM

"It is in the interest of the world community as a whole to accelerate technology cooperation, because without the transfer of environmentally benign technology, global environmental problems promise to undermine the prosperity and security of even the richest nations."[1] The development and diffusion of environmentally sound technologies are essential to a global strategy of sustainable forest management. Countries in the North (i.e. the developed countries) have about 95% of the world's facilities and scientists for research and development and have both the resources and the capacity to develop and implement SFM technologies.[2] In contrast, the limited resources and technological capabilities of the South (i.e. developing countries and economies in transition) impose important constraints on their ability to develop and utilize technologies for sustainable forest management. Thus, the technological requirements of the South need to be addressed, in part, through transfer of financial resources and technology from developed countries. Efforts also need to be made to increase the diffusion of existing and emerging South technologies and traditional forest related knowledge and to expand capacity in the South to develop their own environmentally sound technologies and management practices.

Forests form a crucial part of global ecological, economic and social systems, and degradation of forests poses a particularly severe threat to human survival. The costs of failing to manage forests sustainably include land degradation, soil erosion, watershed damage, a fall in productivity, loss of essential forest products, and tremendous environmental hazards, including an impact on global warming, loss of bio-diversity, and other as of yet unascertainable damages associated with the disturbance of the forest eco-system. Forest eco-systems are complex and difficult to manage, however, and science and technology as well as traditional forest knowledge can make important contributions toward the introduction of SFM.

Technology is construed broadly to include both "hard" technology, in the form of plant, machinery and equipment, and "soft" technology, in the form of training, know-how and efficient organization and management of the production process. Useful transfer of hard technology requires the transfer of complementary soft technologies and a supporting infrastructure. As noted by MacDonald (1992), one of the major constraints

on successful technological development in the South "has been the tendency of hard technology to run ahead of the training, institutional capacity, and infrastructure support necessary to sustain the hard technology."[3] Indeed, since an important challenge in achieving SFM is the need to adapt technologies to the variety of forest systems as well as the changing conditions of forests, the importance of "soft technologies" may very well outweigh the importance of hard technologies. Learning and the ability to innovate are key ingredients in a successful SFM strategy.

Promising Areas of Technological Innovation

The opportunities for contribution of technological innovation to SFM are enormous. Examples of areas in which new technologies may benefit forestry include: "(i) forest resource assessment (remote sensing, computer-based GIS techniques etc.), (ii) intensive wood production (biotechnology and breeding), (iii) forest harvesting and transport, (iv) wood processing and use (saw mill technologies, pulp and paper manufacturing, energy production), and (v) processing and other addition of value to non-wood forest products (fruits, oils, gums, pharmaceutical products, etc.)." [4]

The IPF has concluded that the major problem facing global forests is not the absence of environmentally sound technology in the forest sector, but the dissemination and adoption of this technology. Priorities for technology transfer and capacity building in the forestry sector include: "information dissemination to improve forest and land-use planning and improvement of forest yields; technology and methods that reduce environmental damages due to current forestry practices; conservation and protection; native species research, including biotechnology, for tree improvement; rehabilitation and restoration of natural forest ecosystems; reforestation and nursery development; technology and methods for retaining forest values, including biological diversity; incorporation of indigenous knowledge in forest management; utilization, rehabilitation, restoration and regeneration of natural forest ecosystems; new and renewable sources of energy, in particular fuel wood and its appropriate substitutes; environmentally sound forest harvesting technologies; enhancement of technologies regarding wood processing; the development of new non-wood and wood forest products to promote techniques and design in order to add more aggregate value for forest products; and the development and implementation of national forest strategies."[5]

One area in particular need of attention is the development of methods of assessing the environmental soundness of forest technologies. Developing countries need to establish sound methodologies for identifying and evaluating alternative forest technologies. "The appropriate starting point is the development of appropriate technology assessment methods by employing certain internationally agreed, objective criteria and indicators."[6] Another key area of concern is the need to expand the capacity of developing countries to absorb and utilize new technologies in the forestry sector. While this is a problem endemic to technology transfer in general, the forestry sectors in developing countries have been particularly slow to adapt to technological advances, and few resources have been devoted to forestry research and training programs.

Current SFM management strategies provide important avenues for development and diffusion of SFM technologies. These management strategies can be categorized as: (1) mechanisms to manage existing forests; (2) mechanisms to provide alternatives to deforestation; and (3) mechanisms to manage new forests.[7] Mechanisms to manage existing forests include development of non-timber forest products and commercial forest management through sustainable logging, use of lesser-known tree species and "natural forest management". Non-wood forest products, such as herbal medicines, food, fibers, oils and spices, which are generally confined to localized markets and decentralized trading, have been undervalued and underutilized, and technologies are needed to identify, develop and market these products.[8] Technologies are also needed to identify, assess and market non-traditional uses of forests.

Mechanisms to improve commercial forest management include improvements in harvesting operations and forest-processing industries that can be used to reduce waste and energy usage and damage to forests. Commercial logging affected an estimated 4.4 million ha annually in 1980. Generally no more than 10 percent of the tree species are commercially favored. Without selective harvesting of that 10 percent, these logging practices are both wasteful and damaging to forests, thus efforts need to be made to improve the sustainability of commercial logging.[9] Moreover, the major wood-based industries, which include saw-milling, wood-based panels, and pulp and paper, tend to be energy intensive and create substantial resource waste. Studies suggest that even simple changes in technologies can provide important economic benefits and energy savings.

For example, a study on improvement in NWFP harvesting indicates that improvements in harvesting techniques could increase income by 10 percent or more and improved forest storage and transport could reduce waste by 30 percent.[10]

Mechanisms to provide alternatives to deforestation include agroforestry and devices to reduce end-use demands. Agroforestry involves growing trees and shrubs together with annual crops and possibly livestock, either simultaneously or sequentially. It has been practiced for centuries in a number of countries, and continues to be practiced extensively in a limited number of countries.[11] Technological developments in agroforestry could increase the viability of such a strategy for combating deforestation on a broader scale. Natural forest management (NFM), which involves "integrated multi-purpose management of forest resources under a holistic eco-system approach for wood and non-wood products and benefits," provides a more exciting avenue for SFM. Such an approach allows for a diversification of forest uses and greater scope for non-destructive uses of forests.[12] Finally, devices to increase the efficiency of local fuel use can have an important impact on forest degradation and deforestation. In Kenya, for example, an improved version of the traditional ceramic stove reduced fuel use by 15 to 40% and paid for itself within a few months.[13]

Managing new forests may involve replanting on deforested land, developing plantations on less degraded land, and attempts to restore degraded forests to healthier conditions. Forest plantations have been employed as a component of SFM, with varying success. The reported gross area of plantations in tropical developing countries in 1996 was 43.9 million hectares, with an estimated effective net area of 30,84 million hectares. There have been considerable advances in forest plantation technology, which improve its prospects for the future.[14] For example, Aracruz Florestal, a Brazilian paper pulp company, was able to increase the production of industrial round wood from 28 cu.m./ha per year to 70 cu. m./ha per year through the use of genetically improved hybrids.[15] The opportunities for SFM technological innovation in the South are great but the prospects are currently not encouraging.

2. Impediments to Technological Innovation in the South

While the South could benefit greatly from technological innovation in forestry, a variety of constraints impede such innovation. Lack of funds and facilities, poor institutional capacity, inappropriate policies, and inadequate infrastructure combine to slow down technological innovation, either through local generation of new technologies and/or the transfer of technologies developed in the North. The problem is not only one of sufficient pace of innovation, but also confining innovation to that which promotes local SFM needs. Indeed, adoption of some innovations (e.g. innovative logging methods and equipment) has resulted in faster deforestation and destruction of the forest environment.

General Impediments to Adoption of SFM Technologies

There are several general impediments to SFM and the adoption of appropriate innovative SFM technologies. The economic impediments typically receive the most attention. It is claimed that lack of funds, low rent capture and undervaluation of forest resources, limited mobility of investment capital and imperfections of markets for forest products, trade barriers, and market failures due to externalities, reduce the incentives or ability of enterprises in the South to switch from outdated and wasteful harvesting and processing procedures. Change is difficult because the benefits of SFM innovations are often realized in the long term while the costs are immediate. Long horizons and high risk increase the premium on returns that investors demand. Social constraints include lack of awareness and knowledge of the innovations, resistance to change and lack of compatibility of some innovations with indigenous technologies and practices. Institutional failure also impedes technological innovation. Lack of coherent national plans for forests increases uncertainty and makes it difficult to identify appropriate forest technologies and to develop strategies for their implementation and sustainable use. Lack of clear definition of property rights in the forest and short-term tenure arrangements reduce the incentives of forest users to invest in innovative strategies to ensure sustainability of the resource. Policies that lead to market distortions (e.g. subsidies for agriculture) and under-valuation of forest resources (e.g. harvesting subsidies) can have a detrimental effect on SFM and impede adoption of SFM strategies.

Legal and regulatory barriers to technology transfer and foreign investment also have detrimental effects. On the one hand, strong protection of intellectual property rights (IPR) denies many countries in the South economic access to some technologies. On the other hand, lack of a minimal degree of IPR protection in some South countries impedes transfer of technology as well as the growth of local R&D capabilities.

Pre-Conditions for Successful Technology Transfer

Removing general economic, social and institutional impediments to SFM innovation domestically in the South will contribute to the successful implementation of any specific strategy which targets technological innovation in the South. Thus, correcting market and policy failures in the forest sector, improving forest planning, reducing risks associated with foreign direct investment, and compensating technology users for global and domestic externalities are general preconditions for fostering SFM innovation. Internationally, changes in IPR regimes and competition laws to ensure viable competitive technology markets, improvements in flows of technological information, and correcting market failures in international capital markets (stemming from political risks and high risks involved in SFM research and development) will also contribute to SFM innovation.

To ensure the successful transfer of a particular technology, several preconditions must be met. These include: (1) local demand for the technology; (2) availability of information about existing technologies; (3) supporting infrastructure, including transportation, communication and education; (4) economic viability of the transfer; (5) availability of financing; and (6) appropriateness of the technology in light of the underlying needs of the recipient.[16] To ensure that technology transfers promote sustainable forestry, several additional conditions must be met. These include: (1) adequate capacity of recipient countries to screen investors and technologies to determine if they are appropriate and serve SFM objectives; (2) adequate recipient capacity to regulate forest development according to SFM principles; and (3) adequate capacity for the production of scientific knowledge which permits adaptation of North SFM technologies to the local conditions of recipient countries.

Developing countries currently meet a substantial proportion of their technological needs by importing technology that has been designed to satisfy the needs of the exporting developed countries. These technologies are often ill-suited to the needs of the importing countries. Recipients of technology are often poorly informed about the product and are easily influenced by potential sellers, and both business and political interests may distort the choice of technologies. The identification and selection of "appropriate" technology, i.e. demand-driven technology which can be adapted to local conditions, is crucial for the transfer and adoption of environmentally sound technologies.

The appropriateness of a technology will depend in part on the ability of the recipient to utilize and manage the technology once the donor relinquishes control. Criteria for determining appropriateness include the cost of the technology, the availability and ability to utilize local resources (including the local work force), the complexity of the process, the availability of training, and the role that the technology plays in satisfying the economic needs of the recipient. Additional factors affecting the political economy of the transfer process include the competitiveness of the technology market, regulation and intellectual property rights, national policies affecting tax, foreign investment and trade, and culture. The timing of the transfer in relation to the life cycle of the transferred technology is also of importance, and "technology dumping" should be avoided. In addition to obtaining information pertinent to the specific application of the exported technology, attention should be paid to compatibility with indigenous technology and practices. Local knowledge can be used to inform the selection of appropriate technologies, and failure to incorporate this knowledge could contribute to project failure. Care should also be taken to supplement rather than supplant indigenous capabilities, and the selection process should include an assessment of likely short and long-term impacts of the transfer. Appropriate technologies will be those which incorporate traditional forest-related knowledge and accommodate traditional sustainable forest practices where possible.

3. Choice of Strategy and Mechanisms

The specific strategies chosen for transferring a technology must reflect its maturity or stage in the technology life cycle. The ITFF has identified three technology groups: (i) available technologies that could be better utilized for SFM; (ii) technologies needing increased transfer; and (iii) emerging technologies. The first group includes technologies that are available in developing countries but could be better utilized through strategies such as the design of an enabling policy environment and human capacity development. Examples include improving genetic quality of planting material, tree plantation development, and timber harvesting and processing technologies. The second group includes technologies that have only recently been developed and have not been introduced to developing countries. Investments in training, facilities and operating costs are needed to increase transfer and adoption of these technologies. Limiting factors which need to be addressed include property right issues and high access costs and barriers to some of these technologies. Examples include satellite and GIS-based forest assessment techniques, biotechnology and specialized aspects of tree product processing. The third group includes technologies at the R&D, testing and application stages. Examples include genetic engineering and technologies used in assessing the functions of forests. Participation by developing countries in the development of these technologies can circumvent many of the technology transfer problems associated with transfer at later stages, as well as increasing the scope for incorporating indigenous knowledge and indigenous needs into technology development.[17] Long-term strategies with respect to this group of technologies should include, for example, facilitation of graduate studies for young scientists from the South, joint North-South field laboratories in the South, and exchanges of scientists.

The choice of strategies and mechanisms also depends on the economic characteristics of the strategy, in particular the degree of and nature of the market failure which prevents its adoption in the South. Environmentally sound technologies can be differentiated in terms of their economic viability. Particularly in the context of environmental externalities, many of the benefits of SFM technologies may be difficult to capture, rendering some socially beneficial technologies privately non-profitable.

Environmentally sound technologies can be divided into four basic economic categories: those which are economically viable; those which are economically viable once initial start-up costs have been financed (e.g. viable with seed investment); those which have a net social benefit but yield a negative profit; and those with (opportunity) costs that exceed their social benefits. Strategies for promoting technology transfer can include efforts to transform category two and three investments into category one investments through the development of new environmental markets and through regulation which makes clean and SFM technologies more financially attractive. Different strategies for technology transfer will come into play for different economic categories of technology, with greater public sector involvement in areas which do not generate initial profits.

Below we provide details on the portfolio of optional mechanisms to promote transfer of SFM technologies. We classify the mechanisms into five basic classes representing alternative strategic thrusts. These are not mutually exclusive. Indeed, it is the optimal combination of strategies (strategic mix) that is often necessary to ensure SFM innovation.

4. Mechanisms for Transferring Technology

The broad strategic thrusts are: (A) mechanisms for building capacity (e.g. research and development, education, training); (B) mechanisms for information transfer and diffusion of technology; (C) market-based strategies, including creation of new products and markets for alternative forest uses; (D) private sector initiatives; and (E) public-private partnerships.

A. Mechanisms to build capacity

Building endogenous technical capacity is perhaps the most challenging, but also the most crucial, task in ensuring the sustainability of efforts at environmental protection and sustainable development. This is the strategic thrust which must rely on external public financing to a larger extent than the other thrusts. Endogenous technical capacity refers to the use of science and technology for development, and it can be defined as "the capacity arising from the internal efforts of society to assimilate and use the accumulated

knowledge of humankind in such a way that it serves that society's practical needs."[18] Only by developing such a capacity will a country be able to adapt, expand and improve on existing technologies to satisfy local technological needs. Such a capacity will increase the ability of the recipient to absorb and utilize donor technologies and its ability to implement and manage imported technologies. Indeed, the ability to localize a technology and improve it through learning by doing is essential in forest-related technology, as one must cope with extreme variability of conditions. Expansion of SFM related technical skills will have positive effects on the growth of both the forestry sector and the supporting innovative industries in its cluster in recipient countries, lowering the costs of innovation and increasing the profitability of future investment both in forestry and in the SFM technology sector.

Basic Research Capabilities Developing the capacity for basic forestry and environmental research in developing countries should form a key part of any long term sustainable development strategy. Methods for creating and expanding research capacity include financial support of training of graduate students and technicians, support of local research programs focusing on development of technology, on-site training by foreign specialists, development of local research institutions with capacity to do basic research, and support for research projects involving institutions in developing countries, twinning programs in North-South research and graduate training programs as well as developing cooperative networks of South institutions.

Programs for funding research and educational exchanges can be useful in transferring skills and knowledge to South institutions. Possible strategies include student exchange programs, study tours, exchanges of professionals (both North-South and South/South), scholarship programs and fellowships for researchers from developing countries. Targeted university research funding can be used to encourage research in environmental technologies, particularly SFM technologies, and in related areas. Support could be provided for development of university-affiliated industrial research centers in developing countries. Involvement of the private sector could be facilitated through private sector participation in university-affiliated research programs focusing on technology and through work-study programs involving university students from both developing and developed countries.

Applied Research Capabilities Developing the capacity of developing countries to adapt existing technologies to local conditions and local problems is essential to successful technology transfer. This is especially important in the forest sector, where conditions (e.g. climatic, micro-climatic, soil, species) vary dramatically from region to region and even from site to site. Most of the environmental technologies developed in the North have been designed to address the needs of the North, and modifications may be needed if they are to satisfy the needs of the South in an effective manner. Strategies for expanding indigenous capability to utilize existing technologies include funding adaptations of technologies to recipients' contexts and training programs to facilitate technology adoption and build local R&D capabilities. Sponsoring technical seminars and workshops could also provide a useful mechanism for developing local skills and generating ideas about local uses. Research programs targeted at identifying, refining and extending indigenous environmentally sound technology can be used to incorporate and preserve traditional forest knowledge. Successful applied research must also incorporate industrial experimentation within the field or the plant. This will require improvement of the technological capacities of operational divisions of enterprises. The formation of joint industry-university research institutes in the South may facilitate both the targeting of research in universities to applied problems and the diffusion of new technologies to forestry and industrial operations. Coop programs of training in forestry and forest product engineering may help strengthen technological capabilities of potential technology users. These programs may involve students and firms from both the North and the South.

Training and Consulting Services "Successful diffusion and adoption of environmentally sound technologies depend on the recipients', administrators', engineers', technicians' and economists' being trained or retrained so as to be knowledgeable in available technologies and their potential problems, with the objective of sustainable development informing decisions at all levels..."[19] The creation and/or expansion of a skilled indigenous work force plays a key role in expanding recipient capacity to utilize technology. Training programs and access to support services such as expert consultants (local and foreign) can be used to educate the work force in new technologies and modifications of these technologies. Examples of useful strategies include consulting

services to support recipients of technologies. The scope of the consulting services could include advice and training on technology alteration, identification, choice, and implementation. Training is needed at many different levels of the technology transfer process. Training in decision making about appropriate technology, programs focusing on management practices, and training in implementation can be used to increase recipient capacity.

There are problems which are endemic to some of the mechanisms for capacity building described above. In particular, there are problems of lack of "fit" between training received abroad and the know-how necessary to deal with local "South" conditions, and problems involved with trained professionals from the South remaining in the North. Programs which involve joint work by South and North institutions can lead to mutual learning and the development of training with localized content. By ensuring that trainees remain in the South for most of their program, their local networks and roots remain intact and their post-training absorption into local government agencies and enterprises is likely to be smoother. Models which involve joint training by local and foreign institutes, for example, where degrees or certificates are provided by the local institutes, reduce the mobility of trainees and increase the probability that they remain as part of the capacity built in the South. Such arrangements allow organizations in the North to adapt their programs to the needs of the South without generating resistance within their own organization to the required changes and without threatening the integrity of their programs.

A balance needs to be maintained between basic, applied, and professional training programs. While typically there is pressure to emphasize applied research and professional training programs, it is important to recognize the gap in the South's scientific understanding of local complex forest ecosystems. Building capacity to identify, develop and absorb technologies requires the development of interdisciplinary management skills in the process of technological change. These include the ability to manage the impacts of new technologies on social and economic processes.

An important ingredient in capacity building is the maintenance of continuity and sustainability. In order to be successful and sustainable, a capacity building program must ensure that local support for the program and the program's degree of autonomy

increase over time. Indeed, to secure political acceptability and sustainability, it is important to involve stakeholders in the design of the program. Stakeholders should include not only those directly involved in the program, but also potential users of SFM technologies and those who may be impacted by them.

B. Mechanisms for transferring information and diffusing technology

The process of technology transfer is often impeded by poor systems of communications and information transfer to and within developing countries. This is particularly the case in sectors, such as forestry, which have not been the traditional targets of national industrial policies and in which rural practices and uses predominate. Communication of the needs of recipient countries and information about the technologies available to meet these needs is an integral part of successful transfer, and improved networks of communication can be used both to facilitate technology transfer and to empower recipient countries in the transfer process. Strategies for increasing the transfer of information and diffusion of technology include the following: (1) data gathering and information pooling; (2) networks and consortia; (3) focal groups for technology transfer; and (4) empowerment of ENGOs and environmental advocacy groups.

(1) Data Gathering and Information Pooling A first step in the distribution and diffusion process is to accumulate and distribute information about the parties involved, the technology needed and the technologies available. Public funding from donor countries and multi-lateral organizations may be needed to support capacity building in data gathering and to strengthen national institutions in forest assessment. Data bases on technologies could be compiled and distributed to South countries. Similarly, data bases on indigenous technologies and technological needs could be used to inform suppliers about existing needs, conditions, and capacities.

At an international level, the effectiveness of the transfer process could be improved through greater coordination of individual country activities. This would be aided by an international consensus on certain objective criteria and indicators for assessing SFM, including shared definitions and terminology and the design of international models for assessing SFM.

Mechanisms for preserving, managing and disseminating traditional forest-related knowledge (TFRK) can play an important role in SFM. National mechanisms for incorporating TFRK into forest management strategies and inclusion of indigenous people with TFRK into the national forest planning process could be used to preserve and promote the use of TFRK. International mechanisms for the exchange of information on national experiences and mechanisms could be used to stimulate the protection and application of TFRK, increasing the status of such knowledge bases and facilitating participation of and benefit sharing by indigenous peoples who possess TFRK. The IPF has suggested that the World Intellectual Property Organization (WIPO) undertake a study of the relationship between intellectual property and TFRK, identifying ways of protecting TFRK against illegal international trafficking and national exploitation and ways of ensuring equitable division of benefits from TFRK.[20]

Multilateral institutions have traditionally played an important role in international pooling and exchange of information. Recent examples include the establishment of the United Nations Environment Program's International Environmental Technology Center (IETC) in 1994 to promote the transfer of environmentally sound technologies to developing countries and economies in transition. The IETC provides training and technical assistance, and accumulates and disseminates information.[21] A current initiative spearheaded by the FAO is to prepare a strategic plan for assessing global forest resources for the year 2000.[22] The creation of a global center for information distribution and diffusion of SFM technologies and technical know-how under a multilateral umbrella may help to form a global SFM technology pool and encourage technology sharing. To be successful, it will require the support of a research effort to integrate specific local knowledge and experiences both in the South and the North, as well as resources to compensate both South and North technology contributors for losses of intellectual property rights. Regional and national centers affiliated with the Global Center will provide windows for technology for end-users and the means for local information collection and sharing.

(2) Networks and Consortia Technologies and information have properties of public goods. They do not perish with consumption and the marginal costs of additional users are negligible. The economies to scale and scope that are present suggest the

benefits of collaboration between organizations. Networks and consortia represent a class of forms of inter-organizational collaboration. Such collaboration is limited to certain activities of participating organizations and thus maintains their autonomy. The degree of collaboration and the degree of formality of the agreements that guide the collaboration and the type of institution that manages it vary significantly. This can range from establishing a new corporate body to informal exchange relationships based on trust. The choice of form reflects the stakes involved, the history of inter-organizational relationships and the business culture of the parties involved. Networks and consortia are based on exchange relationships between the partners. In addition to information sharing, such forms of collaboration encourage capacity development in partners. Since relationships between network members are continuous, they permit mutual learning by members. An excellent example of an SFM network is the International Model Forest Network (IMFN). The primary goal of the network was to "establish a global network of model forests that will represent most of the major forest eco-systems in the world, and to ensure that all partners, regardless of political and economic status, can contribute to, and share in, the benefits of the network as they work toward the sustainable management of forest eco-systems."[23] Participants will produce knowledge which they will share with other members. The network fosters cooperation and exchange of ideas relating to the working concept of sustainable forestry. It will also promote international cooperation in critical aspects of forest science and social science that underlie the search for new models of SFM.

Consortia are often established with stronger (and sometimes independent) management mechanisms. They are less inclusive than networks such as the IFMN, and their collaboration may go beyond exchanges of information to the collaborative generation of new proprietary information and technologies. Examples of types of consortia include research consortia and buyer consortia.

Research consortia can be used to provide valuable opportunities to expose the South to new areas of research and new methods for engaging in research. They can be used to connect institutions in the South with other South institutions and with institutions in the North. Possible arrangements include university consortia, university-government-private sector consortia, private sector consortia, and private sector-

government consortia. The creation of sub-regional and regional networks of research institutions offers opportunities for institutions with relatively similar research interests, needs and constraints, including similarities in forest conditions, to share information. It may also provide opportunities for exploiting synergies. Mechanisms such as university-industry networks at the regional and national level are needed to transfer research findings to policy and field levels.

Buyer consortia may be established to gain market power when the size of each individual member is too small to influence the market. Buyer consortia with membership from South countries, for example, can be effective bargaining agents with donors and SFM technology suppliers from both the North and the South. Indeed, collaboration by networks and consortia of South members not only increases their bargaining power vis-à-vis the North, but also reduces the costs of moving towards collective self-reliance in their capacities to generate SFM technologies, increases their ability to effectively assess technologies from both the North and the South , and supports regional training and information exchanges.

The promotion of networking requires some regulatory modifications in competition laws and strengthening of regulations in both the North and the South that deter excessive opportunistic behavior. Multilateral organizations can also contribute to the formation of such networks and consortia by developing partner matching services and/or taking an active role in establishing research consortia for SFM. The establishment of international research centers such as the Center for International Forest Research (CIFOR) are examples of the benefits that can be derived from international collaboration. CIFOR, in conjunction with international experts and relevant organizations, could be used to develop mechanisms for identifying and prioritizing global and eco-regional interdisciplinary research problems and to develop consortia or networks to organize forest researchers and global capacity for forest research.[24] Actions could be taken to expand research initiatives undertaken under the CBD, the FCCC and the CCD. International Coordination Centers for Research, Innovation and Technologies with the task of identification and assessment of problems, technologies and technology capabilities can facilitate the establishment of both technology supplier consortia as well as supplier-buyer consortia.

The support of informal collaborations of research institutions is another way that governments and multilateral organizations can foster exchanges of information. The International Union of Forestry Research Organization (IUFRO) provides an example of an excellent economical network for information exchange through regional and global conferences, workshops and publications.

(3) Focal Points for Technology Transfer Developing accessible focal points for technology information dissemination and assessment increases the visibility of technological opportunities and facilitates interest from potential users. SFM Technology Parks in developing countries may increase interest in technological innovation, as well as improve the understanding of technological options the forest sector has. Technology parks may facilitate technological innovation through agglomeration economies, providing, for example, common skilled labor markets and infrastructure services. Establishing technology parks is expensive and risky. It must involve substantial investment by the private sector, and its design, scope and scale should reflect the potential market for its services and products. Focal points for technology diffusion may not necessarily be physical locations. Use of certain multilateral organizations or industry-wide groups (e.g. forest product manufacturing associations) as virtual points for technical information and dissemination may also reduce search costs for small and medium enterprises and thus increase their access to technologies. This, however, requires appropriate promotion and the establishment of specific access channels (e.g. information fax-lines, technology offices).

(4) Empowerment of NGOs and Advocacy Groups Interested in SFM Environmental NGOs (ENGOs) provide an important source of information about innovative SFM technologies. The rapid progress in information technologies has led to the internationalization of these groups and increased significantly their reach. Many of these groups, using international virtual networks of volunteers, assemble impressive databases about technologies and develop access to various networks of experts. In many locations these groups have also developed means of commanding public and media attention. They are thus ideally positioned to disseminate information about SFM technologies and capture the attention of potential users. Supporting some of the more responsible groups to develop further their capabilities (in particular, ensuring improved

quality control over information collected) may be an effective means not only to provide access to information but also actively to encourage potential users to pay attention to the information. The empowerment of NGOs may also increase pressures on domestic governments to provide additional resources for the development, acquisition, and implementation of SFM technologies. Such groups are also more likely to follow up adoption of new technologies and monitor whether they contribute to SFM.

C. Market Strategies

Market-based strategies that the government in the South can undertake include the development of legal, policy and market infrastructures to facilitate technology development and transfer under business conditions using market-based instruments (subsidies, taxes, user fees and trading arrangements). The advantage of this approach is that it uses public funds only to leverage private sector resources in the technological innovation process. As we have pointed out in a previous section, the amount of public funds necessary will depend on the amount of externalities that cannot be captured by the private adopter of the SFM technology, the degree of risk involved and the relative burden imposed by start-up costs.

A government has a responsibility to ensure that functioning market mechanisms are in place to facilitate, wherever possible, transfer of technologies under business conditions. The government should provide for the development of appropriate infrastructure that can support the new technologies, ensure that appropriate legal strategies are in place to define and guarantee property rights, remove both distortionary subsidies and taxes, correct for capital market failures, help reduce risks by providing insurance against excessive risks, insure competition in technology markets, internalize benefits through subsidies, and tax negative externalities. The government should help to overcome capital market imperfections by providing financial incentives to SFM innovation, employing cost-sharing and co-financing schemes to ensure that start-up costs are not a barrier. It should provide temporary price supports to help develop new markets to provide opportunities for profitable exploitation of new technologies and products and to offer incentives to expand indigenous technological capabilities.

The constraints that governments in the South face when attempting to correct market failures are enormous. Most of these constraints arise from a lack of resources and capacity. Many governments in the South face significant challenges in reforming their fiscal systems and lack capacity to properly administer a system of R&D incentives (such as tax credits and subsidies). Many do not have the administrative capacity to prevent fraud or to ensure that tax benefits are not captured by rent seekers with little stimulation of investment in SFM technologies.

Reducing risk through insurance requires investment by players outside the South because concerns about the stability and economic ability of South organizations are often the root cause of the perceived high risks of investing in the South.

Correcting market failures in the North with respect to technology diffusion to the South is equally important. Many governments in the North already have in place a complex system to correct market failures in the technology market. Governments in the North encourage R&D investment by a variety of means, including: (1) direct spending (e.g. funding government labs and R&D contracts); (2) provision of scientific and technological assistance at less than market prices; (3) tax credits; (4) direct subsidies to R&D establishments; (4) support of infra-structure development; and (5) public training programs. These programs can be modified to encourage SFM technology development and exports of such technologies to the South. Governments in the North may extend such benefits to SFM technology firms operating in the South to reflect the global benefits that can be derived from improved forest management. To ensure coordination and efficiencies, direct assistance to the South is best accomplished through multilateral agencies that involve both donors and recipient countries and NGOs. The funding of technological improvements and transfer to the South under the FCCC provides an example of such a coordinated effort to internalize global benefits into private enterprise decision making. Asymmetries of information and lack of competition in technology markets are also important causes of failure. Ensuring competition and regulating against opportunistic behaviors could also promote technology transfers to the South.

D. Private Sector Initiatives

Public sector financial resources in the South are limited and external aid resources are not likely to climb. Significant new money for technology transfer must

come therefore from the private sector (domestic and international). A number of different arrangements are used to transfer technology through private transactions, involving various degrees of collaboration between suppliers and recipients. A company can sell or license patented technology to a local enterprise or government, for example, or establish branch plants. Joint venture arrangements and partnership agreements between North and South companies, or between South government agencies and North based commercial enterprises, offer a way which may involve local companies more intimately in building capacity to manage technological innovations. Multinational corporations can transfer technologies between branches operating in different countries. Contracting for packages of technology and associated services provides yet another alternative. In all, there are six different types of private sector initiatives that involve transfers of technology: (1) direct transfer from supplier to recipient; (2) direct investment; (3) venture technology funds; (4) public-private initiatives; (5) private and private-public strategic alliances and research consortia; and (6) certification and other "demand side" initiatives.

(1) Direct Transfer of Technology from Supplier to Recipient

Licensing is one of the most frequently used forms of carrying out technology transfer between private supplier and recipient.[25] Licensing tends to be costly and retains control in the hands of the supplier. Other types of transfer mechanisms include sale of equipment, technical services, turnkey contracts (in which the supplier builds and implements the technology before transfer) and management contracts (in which the supplier manages the technology). Joint venture agreements or partnerships between private companies or between private and public entities to develop or transfer technology are often used as alternatives to licensing. Contracting for packages of technology and associated services provides yet another alternative. The contracts can include buying, transporting and setting up plant and equipment, contracting for technical assistance and training programs, and "turnkey" arrangements whereby the contractor provides a fully operational plant. A mixture of these mechanisms could be arranged through a public or private development assistance corporation which provides a package covering the right to patented technologies, technical assistance and training, and financing of the new technologies and their implementation.[26] Different arrangements

offer different opportunities for local capacity development and local control of the technologies. In SFM technology transfers the "soft capital" is an important component of the technology package, and thus arrangements must be secured to ensure the development of local capacity.

(2) Direct Investment and Joint Ventures

Caves (1996) found that there is overwhelming evidence that TNCs invest heavily in training in developing countries. Indeed, it is not the capital flows of FDI that make the most important contribution to economic growth, but rather the investments that are made in developing local capacity and the transfer of technologies. Foreign companies can purchase interests in local companies or can form partnership agreements with these companies. Joint ventures between multinational and local manufacturing companies can provide local companies with access to advanced environmental and SFM technologies that increase the eco-efficiency of production processes. Scope for cost savings through eco-efficiency measures will make such investments profitable for local companies. For example, the non-profit group Promotion of Eco-efficient Latin American Small Business (PROPEL) has helped Colombian tanning factories to reduce their operating costs and pollutant discharges through the introduction of clean technologies into the hide preservation and tanning process, reducing pollutant discharges by 50%, lowering production costs by 11%, and allowing an increase in output.[27]

TNCs Transnational firms play a central role in the diffusion of new technologies. The International Cooperative for Ozone Layer Protection (ICOLP), which has distributed methods for replacing CFCs in industry world-wide, provides a good example of how TNCs can forge commercial networks from their global networks of suppliers and affiliates.[28] The World Resource Institute (1997) identifies three steps needed to forge commercial networks for environmental technology diffusion: (1) careful targeting of a problem relevant to them by firms in the network; (2) identification of a catalyst, either private, government, or multilateral, to spark action; and (3) systematic assembly of information about technical solutions and development of structured technical assistance/ technology diffusion arrangements. Measures are needed to encourage the involvement of TNCs in the transfer of technology.

(3) Venture Technology Funds

Mechanisms for indirect private sector environmental investment include commercial lending, portfolio investment, and targeted investment funds such as environmental venture funds. Creation of environmental technology investment corporations could be used to make capital and technical management expertise available to developing countries.[29] A staff with expertise in finance, international transactions and environmental technology management, and familiarity with local conditions, could be employed to target investment opportunities in emerging sectors. Such a corporation could be initiated through public funding and sustained through private investment.

(4) Public-Private Partnerships

Sector-specific environmental technology intermediaries could be used to facilitate technology transfer. The main functions of such a forestry-related institution would be to identify useful sources of SFM technologies, acquire rights to such technologies or act as agents for the licensor, locate potential users, purchasers or licensees, facilitate arrangements between principals, and provide management, technical and other assistance.[30] The United States-Asia Environmental Partnership (US-AEP) provides an example of such an intermediary. It matches Asian environmental needs with U.S. environmental technology and practices, focusing on training and the collection and dissemination of case studies that illustrate the concepts and technical applications of cleaner industrial production technologies.

(5) Private and Private-Public Strategic Alliances and Research Consortia

Strategic alliances or consortia are used to share risks and costs involved in the development of technology. They allow the development of long term relationships between developers of technologies and their users without merging their operations and losing their autonomy. Sectoral research consortia are often organized to help companies in a particular sector jointly develop technologies to meet regulatory requirements. As we have indicated in a previous section about government-led research consortia, such consortia may involve a mix of public and private enterprises. Private sector strategic alliances and research consortia provide excellent opportunities for South and North firms to pool resources and obtain synergies from R&D collaboration (e.g. South companies may bring to the consortia local marketing knowledge and knowledge of the

forest, for example, while the North companies may bring their technical and scientific capabilities to generate systematically appropriate SFM technologies for South forests).

(6) Environmental Certification and other "demand"-side initiatives

We have focused on the supply side of private involvement in SFM innovation. NGO and industry involvement in the "demand" side may create the appropriate incentives for South firms to adopt SFM innovations. Certification processes help create the derived demand for new SFM technologies. To ensure market access, many companies (especially multinationals) seek independent certification of their adherence to SFM principles. The impact of certification is growing rapidly as the membership of buyer clubs of wholesalers and retailers who insist on buying only certified wood increases. The certification process itself often involves technology transfer and helps change practices by diagnosing forest operations and suggesting improvements to achieve SFM. The learning process that is achieved through certification is especially effective in transferring technologies to small and medium enterprises. As certification processes spread to the South they are likely to provide excellent vehicles for soft-technology transfers.

The development of industry-wide voluntary codes of conduct can encourage self-monitoring and indirect enforcement through the market. For example, commitment by forestry and forest related technology companies to promote SFM in the South may be institutionalized through a code of conduct articulated by an industry-wide organization, or by a multi-lateral agency, or embodied in a convention. Provided that performance can be monitored and reported, the market will provide incentives for compliance. South countries may, however, resist such voluntary programs if they consider them as offering market advantages to North enterprises. Certification programs and the articulation of codes of conduct may help channel technology transfer into the paths that contribute to sustainability. Empowerment of local ENGOs as well as international ENGOs may increase the reach of enforcement through the market. Such enforcement is relatively inexpensive, but may be manipulated by protectionist interest groups to reduce market access.

Conclusions

Technology innovation in the South faces economic and social as well as policy and institutional barriers. To facilitate indigenous innovation and technology transfers, efforts must be made to correct market and policy failures. In particular, it is necessary to ensure that demand is created for innovative SFM technologies and that the local capacity to absorb and implement the innovation effectively is developed. This may involve internalization of global and domestic public goods financed by external aid and the domestic public sector.

Information asymmetries in technology markets also constitute an important barrier to technology transfer. Global pooling of technology information and aggressive distribution through multilateral technology-dedicated agencies may provide windows for South end-users of both North and South technologies. Northern technology developers must also recognize the special condition of the South and adjust their technologies appropriately to accommodate indigenous technologies, forest conditions, and the socio-economic needs of the South.

Innovation may not necessarily contribute to SFM and may not be appropriate for a particular country and its special forest conditions and socio-economic and cultural requirements. Capacity to identify, evaluate, modify where necessary, and regulate new technologies (especially those technologies developed in foreign countries to meet foreign conditions) is a key to ensuring that new technologies are compatible with SFM in a particular location. Agencies to screen technologies both at the national and international levels could facilitate appropriate selection of technologies.

Governments in the North and South can use economic instruments to overcome barriers to SFM innovation. These tend to be more efficient means to bring about technological change than prescriptions of specific practices and technologies.

The problem that the use of economic instruments in the South faces is a lack of resources and capacity. The North can modify the use of economic instruments already in place in technology markets to encourage the development of technologies appropriate to the South and to disseminate these SFM technologies.

FDI and a variety of partnerships between South and North contribute significantly to the transfer of technologies and the development of domestic

technological capacity. The higher the active involvement and control of South stakeholders in the technology transfer process, the sooner capacity is built to absorb and develop new technologies. Thus, joint ventures and consortia could be effective mechanisms to encourage transfer and capacity building. Weak institutions and obtrusive regulations discourage FDI. FDI can be facilitated by appropriate tax and regulatory policies, not only in host countries but also in home (or source) countries. Source countries may offer special incentives (paying, for example, the incremental costs of technologies to cover their externalities realized as global benefits).

Competitiveness of technology markets must be maintained to ensure that prices paid by the South are not excessive.

Political risks associated with FDI can be reduced by subsidized insurance and international agreements guaranteeing the rights of foreign investors. Technological transfer to the South can be facilitated by IPR policy modifications that ensure preferential access of South enterprises to SFM technologies but respect the rights of developers.

The process of ensuring SFM-related technological innovation in the South is complex and challenging. It requires the application of multiple mechanisms over a long period of time. To ensure economic sustainability, investment must be based on "patient money." To ensure political and social sustainability, the process of transfer must actively involve recipient stakeholders and help build their capacity.

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[1] Tolba, M. 1992. *Statement by Executive Director of the UN Environment Program to the International Panel to Review Business Progress towards Sustainable Development*, United Nations, New York.
[2] Ramphal, S. 1993. "Beyond Mere Survival." *EPA Journal*, April-June, pp.10-30.
[3] MacDonald, G. 1992. "Technology Transfer: The Climate Change Challenge." *Journal of Environment and Development*, vol. 1, no. 1, pp. 9-30 .
[4] IPF. 1998. *Promoting and Facilitating the Implementation of IPF's Proposals for Action*, June 1998, United Nations, New York.
[5] IPF. 1997. *Report of the Ad Hoc Intergovernmental Panel on Forests on its Fourth Session*. Feburary 1997, United Nations, New York, at 75.
[6] IPF. 1998. *Promoting and Facilitating the Implementation of IPF's Proposals for Action*, June 1998, United Nations, New York.
[7] Levenson, H. and Bierbaum, R. 1992. "Managing tropical forests." *ATAS Bulletin*, issue 7, spring, pp.59-73; Chandrasekharan, C. 1996. "Cost, Incentives and Impediments for Implementing Sustainable Forest Management." Paper presented at the *Workshop on Financial Mechanisms and Sources of Finance for Sustainable Forestry*, Pretoria, South Africa.
[8] The estimated global value of forest foods, for example, is about US$20-25 billion . See IFFP. 1998. *Valuation of Forest Goods and Services; Economic Instruments, Tax Policies and Land Tenure; Future*

Supply and Demand of Wood Products and Non-Wood Forest Products; and Rehabilitation of Forest Cover, United Nations, New York.

[9] Levenson, H. and Bierbaum, R. 1992. "Managing tropical forests." *ATAS Bulletin*, issue 7, spring, pp.59-73.

[10] Clay, J.W. 1995. "An Overview on Harvesting, Forest Processing and Transport of Non-wood Forest Products." Paper for the *International Expert Consultation on Non-Wood Forest Products*, January 1995, Yogyakarta, Indonesia.

[11] In Bangladesh, for example, homestead forests are the most important source of wood, bamboo and non-wood forest products, where some 10 million households supply about 5 million cubic meters of wood from an intensive and efficient system of agro-forestry. In Guatemala, thousands of farms are planting a mix of tree species to produce poles, fodder, fuelwood, fruits and other crops and to stabilize slopes. Levenson, H. and Bierbaum, R. 1992. "Managing tropical forests." *ATAS Bulletin*, issue 7, spring, pp.59-73

[12] Chandrasekharan, C. 1996. "Cost, Incentives and Impediments for Implementing Sustainable Forest Management." Paper presented at the *Workshop on Financial Mechanisms and Sources of Finance for Sustainable Forestry*, Pretoria, South Africa.

[13] Levenson, H. and Bierbaum, R. 1992. "Managing tropical forests." *ATAS Bulletin*, issue 7, spring, pp.59-73.

[14] Chandrasekharan, C. 1996. "Cost, Incentives and Impediments for Implementing Sustainable Forest Management." Paper presented at the *Workshop on Financial Mechanisms and Sources of Finance for Sustainable Forestry*, Pretoria, South Africa.

[15] FAO. 1993. *The Challenge of Sustainable Forest Management: What Future for the World's Forests*. Rome.

[16] The International Environmental Technology Transfer Board, EPA, 1989

[17] ITFF. 1998. *Transfer of Environmentally Sound Technologies to Support Sustainable Forest Management: Report of the Secretary-General*, UN, New York.

[18] Resendiz-Nunez, D. 1992. "Sustainability and the nature of development." *Advanced Technology Assessment System*, issue 7, spring, pp. 13-18 at 15.

[19] Presentation to Agence de cooperation culturelle et technique. 1991. *Strategies and mechanisms which favor technology transfers for sustainable development.*

[20] IPF (1997) Report of the Ad Hoc Intergovernmental Panel on Forests on its Fourth Session. New York, Feb. 1997.

[21] World Resources Institute. 1997. *Rio+5: Technology Transfer*. New York.

[22] FAO. 1996. *FAO Expert Consultation on Global Forest Assessment*, Finland.

[23] International Model Forest Network. 1990.

[24] IPF. 1997. *Report of the Ad Hoc Intergovernmental Panel on Forests on its Fourth Session*. United Nations, New York, p. 94.

[25] Licensing Executives Society International. 1987. ACCT 1991.

[26] MacDonald, G. 1992. "Technology Transfer: The Climate Change Challenge." *Journal of Environment and Development*, vol. 1, no. 1, pp. 9-30 at 21.

[27] Guzman, E. 1995. "A New Paradigm: Eco-efficiency in Small and Medium Enterprises." U. PROPEL.

[28] World Resources Institute. 1997. *Rio+5: Technology Transfer*. New York.

[29] Ibid.

[30] Ibid.